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June 19, 1981
EF2 - 53,816

Mr. L. L. Kintner
Division of Project Management
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Kintner:

Reference: Enrico Fermi Atomic Power Plant, Unit 2
NRC Docket No. 50-341

Subject: Fuel Pool Cooling System -
Additional Information

Attached is one copy of the draft responses to questions on the High Density Spent Fuel Storage System.

Also attached is one copy of a revised FSAR Section 9.1.3 that incorporates the information consistent with the response to the above mentioned questions.

It should be noted that the RHR cooling capacity is greater than that identified during our meeting on May 14. This increase is due to the use of increased flow to the pool and lower service water temperature used in the most recent calculation.

This information will be included in a forthcoming FSAR amendment.

Sincerely,

W. F. Colbert
W. F. Colbert
Technical Director
Enrico Fermi 2

WFC:jl
Attachments

cc: Mr. B. Little

B001/1

A

Response to NRC Questions
Enrico Fermi Unit 2 High Density
Spent Fuel Storage System

1. A criticality analysis for fuel assembly movement around the perimeter of the conventional aluminum storage racks containing fuel assemblies is in progress. The results of the analysis are expected to be available for transmittal to the NRC by May 26, 1981. This analysis will consider only one fuel assembly to be in the perimeter region. The available overhead handling facilities would not permit the handling and/or movement of more than one fuel assembly at a time. Additional fuel assemblies in the perimeter region would first require an unauthorized release of a fuel assembly in the region, and then retrieval of an additional assembly for movement to the same region. Both of these actions would be a violation of administrative procedures. In addition, the geometry of the fuel assemblies would not permit stable "stacking" of an assembly outside the racks. Edison does not therefore consider the existance of more than one fuel assembly in the perimeter region of the conventional aluminum storage racks as a credible scenario.

2. (a) Refueling cycles of one-quarter core every 12 months, one-third core every 18 months, and a combination of these two cycles have been analyzed for 21-day and 30-day cooling. The discharge cycles which results in the highest normal refueling cycle decay heat is a one-third core 18-month cycle with 21-day cooling. The attached revision to Figure 9.1-25 shows that this worst case results in a decay heat which is below the heat removal capability of the fuel pool cooling system.

(b) The minimum elapsed time between shutdown and when all of the discharge fuel is in the spent fuel storage pool will depend upon the number of assemblies that will be discharged. For normal refueling, this will be

21 days consistent with the cooling period used in the normal refueling decay heat calculation.

(c) All calculations have been prepared using ASB Technical Position 9-2. The values of decay heat have been recalculated using a 100 percent power factor.

(d) The worst case normal refueling cycle as covered in Item 2a above has been plotted on the attached revision to Figure 9.1-25. The RHR System heat removal capacity is not shown on this figure, but it is well above the heat removal capacity of the FPCCS.

(e) The fuel pool cooling system heat exchanger design duty as previously shown in Table 9.1-1 was conservatively calculated based on 100°F reactor building closed cooling water (RBCCW) system temperature. In accordance with footnote (a) of this table, the maximum RBCCW temperature is actually 95°F resulting in an actual total system heat exchanger duty of 10.0×10^6 BTU/hr. Revised Figure 9.1-25 now shows that the maximum normal cumulative heat load will not exceed the rated capacity of the ~~spent fuel pool cooling (SFPC)~~ FPCCS system. Accordingly, the RHR system will not be required to augment the ~~SFPC~~ FPCCS system for any normal refueling.

(f) We have determined the worst case maximum cumulative decay heat to occur after 288-hr decay, 180 days after the final normal core discharge (2.0 cores in the pool). The attached figure shows that this heat load is below the heat removal capability of the RHR system when aligned to the ~~fuel pool cooling~~ FPCC system.

(g) The ~~fuel pool cooling~~ FPCC system is not designed to remove decay heat for a full core discharge but for normal cumulative heat loads as outlined in Item (e) above. Since the full core is in the spent fuel pool and the heat removal capacity of the RHR System bounds this heat load case, the time before the heat load would decay to a value equal to the capacity of the FPCCS would not be of concern.

(h) The method for verifying that the decay heat load in the pool is equal to or less than the capacity of FPCCS will be described in an operating procedure. One possible method would be as follows:

(1) When the pool temperature had been reduced to less than $125^{\circ}F$, the RHR pump would be shut-off, and the cross-tie valves closed.

(2) The FPCCS valves V8-3006 and V8-3253 would be opened and the FPCCS pump(s) started. The FPCCS heat exchangers would be either by-passed or the service water (RBCCW) to the heat exchangers shut-off.

(3) The temperature in the fuel pool can be determined from temperature element TE-NC 0 (in the pump suction line). TE-N010 has a strip recorder which plots temperature versus time for a range of zero to $200^{\circ}F$ in increments of $5^{\circ}F$.

(4) Verification that the FPCCS heat removal capacity is greater than the pool heat load would be established by comparing the measured temperature rise rated to a predetermined rise rate representing the FPCCS heat removal capacity. The predetermined rise rate value would be based on the existing service water temperature (RBCCW), and the sensitivity of the temperature recorder.

3. At the maximum heat load determined in response to Item (f) above the pool will rise from $125^{\circ}F$ to $212^{\circ}F$ in 8.5 hours and the boil off rate will be 8.4 lbm/sec. Coolant can be added to the pool (if necessary)

from the RHR SW System through the RHR System, the Condensate Storage System, Firefighting System, or from the torus (since the full core is in the fuel pool) through the RHR System. The quantity and make-up rate for each of these sources is tabulated below:

Make-up Source	Quantity Available	Make-up Rate
RHRSW	6,930,000 gal.	2000 gpm (one pump)
Condensate Storage	600,000 gal.	100 gpm
Fire Protection	Lake Erie	500 gpm (minimum)
Torus	1,000,000 gal.	5400 gpm

It is anticipated that make-up from each of the above sources could be provided to the spent fuel pool in less than an hour.

4. The revised calculations for 100 percent power factor ~~give~~ resulted in a revised de-decay heat valve of 9.9×10^6 BTU-hr. This heat load will result in a pool temperature rise from 125°F to 212°F in 26 hours. The discussion of the plant conditions leading to the availability of the RHR System for fuel pool cooling were previously provided in Edison's response to NRC question #020.24 (FSAR Appendix E, page E.2.020-30).
5. Back-up cooling is provided to the fuel pool by means of a permanently piped cross-tie to the RHR System. In this mode of operation one RHR pump and the corresponding RHR division heat exchanger will provide the means to cool the fuel pool. This cooling circuit is established by opening cross-tie valves V8-3264 and V8-3029 and closing FPCCS valves V8-3006 and V8-3253 (see figure 9.1-23). For the designed piping configuration, the RHR pump will deliver approximately 5400 gpm, and the RHR heat exchanger will remove approximately 35×10^6 BTU/hr at 125°F pool water temperature and 89°F RHR service water temperature. To

insure the availability of back-up cooling via the FHR System, the cross-tie piping, the FPCCS piping from the skimmer tanks to the first anchor downstream of valve V8-3006, and the FPCCS piping from the first anchor upstream of valve V8-3253 to the fuel pool diffusers are Category I.

6. The FSAR states the spent fuel storage racks and their supports are designed to withstand an impact energy of 2000 ft-lb from a falling object. (Section 9.1.2.1.) The NRC requested we verify this for all items normally carried over the racks. The attached table gives the results of the study made in response to this request.

The kinetic energies were computed including the effects of drag and bouyancy. The study shows three items - fuel bundle, control rod guide tube, and blade guide - exceed 2000 ft-lb. if dropped from above the pool surface. Administrative procedures will require these items to be inserted and withdrawn from the pool in an area which does not contain racks. No restrictions are necessary for carrying three items at normal heights during transfer from the pool to the r- ctor vessel.

Kinetic Energy of Items Dropped
Into Fuel Pool

Item	Weight (lbs)	Kinetic Energy (Ft-lbs)	
		From 40-in. Above Rack	From 30-in. Above Pool
Fuel Bundle	700	2000	
Control Rod Guide Tube	257	860	
Orificed Fuel Support	62		100
Control Rod	250		1400
Vacuum Cleaner	150		80
Actuating Pole	81		1800
Fuel Support Grapple	87		130
Control Rod Grapple	17		380
Fuel Bail Cleaner	50		50
Defective Fuel Storage Container	190		1050
Blade Guide	180	600	

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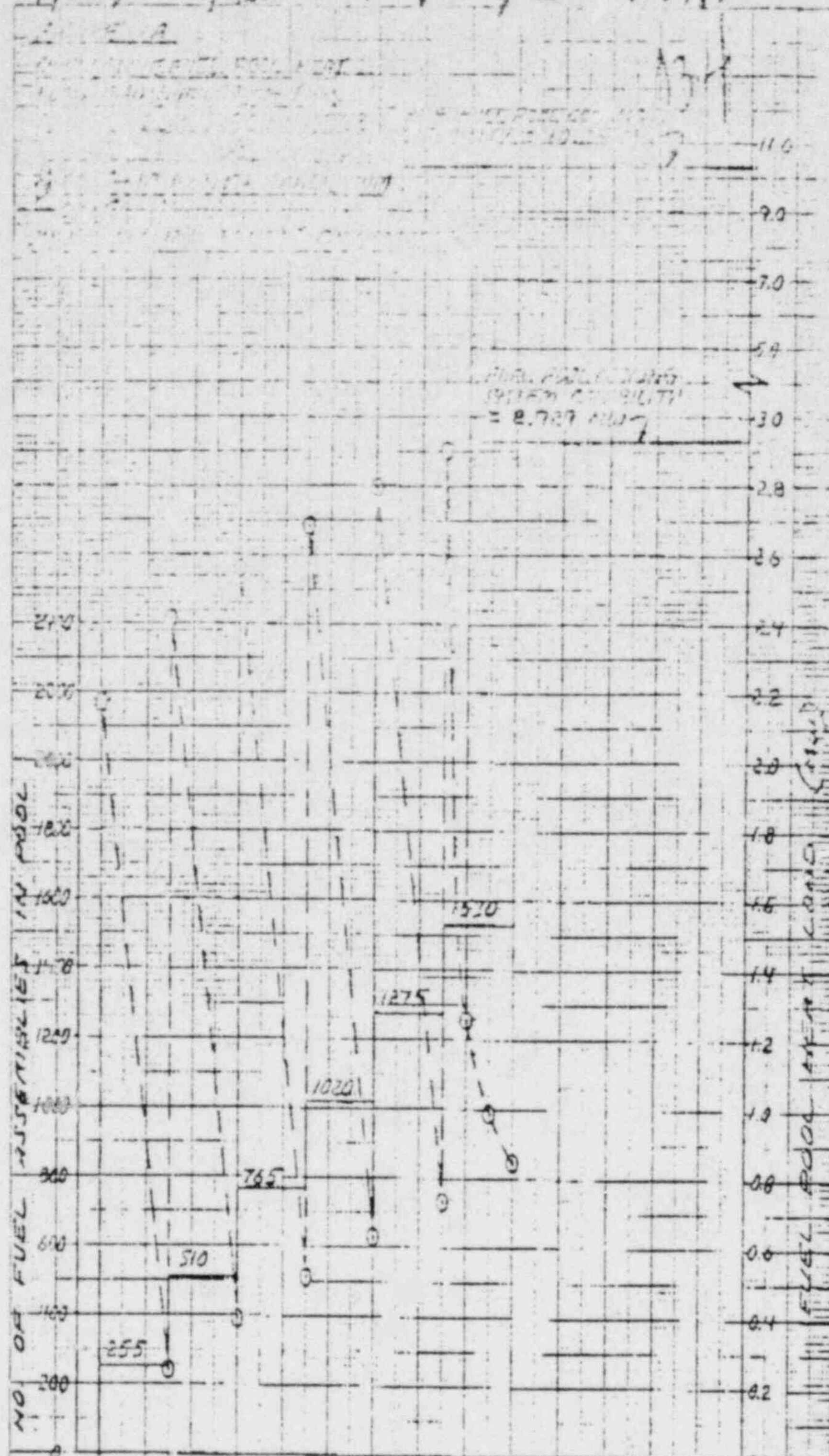

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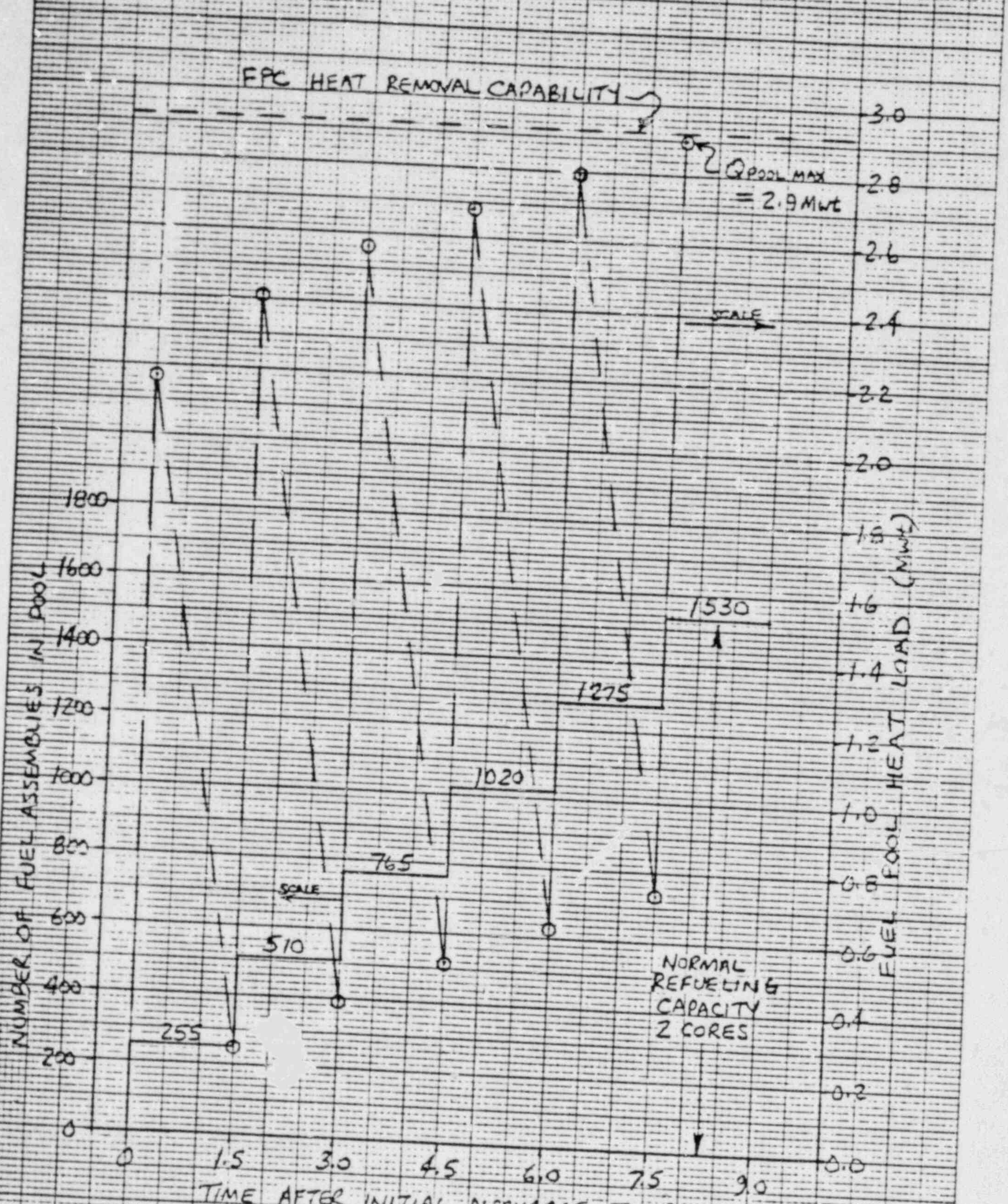

CASE:
1/3 CORE, 18 MONTH CYCLE
t_o = 4 1/2 YRS, t_s = 21 DAYS

FIGURE 9.1-25
CUMULATIVE POOL HEAT LOAD AND FUEL ASSEMBLY STORAGE

9.1.3 Fuel Pool Cooling and Cleanup System (FPCCS)

The fuel pool cooling system is designed to remove the decay heat produced by stored spent fuel assemblies during all anticipated conditions of plant operation and refueling. The system consists of two identical trains, which include pumps, heat exchangers, and filter demineralizers.

The design criteria for the fuel pool cooling system are as follows:

a. The spent fuel pool storage capacity is, nominally 2.1 cores, plus room for removing a full core.

b. Both one-quarter core 12-month and one-third core 18-month fuel discharges are conceivable refueling cycles for Fermi 2. Depending upon the actual refueling cycle, the maximum spent fuel population may be comprised of one of the following:

1. 2.0 cores comprised of eight groups of spent fuel assemblies, each group containing a number of assemblies approximately equivalent to one-quarter core discharged into the pool annually.

2. Slightly less than 2.0 cores comprised of seven groups of spent fuel assemblies, six groups containing a number of assemblies approximately equivalent to one-quarter core discharged annually and one group containing a number of assemblies approximately equivalent to one-third core discharged 12 months later.

3. 2.0 cores comprised of six groups of spent fuel assemblies, each group containing a number of assemblies approximately equivalent to one-third core discharged every 18 months.

c. The spent fuel assemblies have a power history giving the discharge batch an average irradiation $\leq$30,000 MWd/MTU.

d. The maximum normal bulk pool temperature is 125°F.

e. The decay heat was calculated for the various fuel populations described in b.1, b.2, and b.3, above, based on Branch Technical Position ASB 9-2, Revision 1. The following assumptions are made to calculate decay heat load to the pool:

1. For cases b.1 and b.2, each discharged assembly has been irradiated for 4 years.
2. For case b.3, each discharged assembly has been irradiated for 4-1/2 years.
3. During the irradiation period, the reactor is operating at [redacted] 100 percent power [redacted].
4. After shutdown, the RHR cooling system is used for 21 days while the reactor head is off and refueling/maintenance operations are proceeding.
5. In applying Branch Technical Position ASB 9-2, Revision 1, the uncertainty factor K for irradiation time $t > 10^7$ seconds is taken to be 0.1.
6. The decay heat contribution from the heavy elements (U-239 and Np-239) is ignored because, during the time of interest ($t > 21$ days), the

heavy element decay heat is less than 0.2 percent of fission product decay heat.

f. The FPCCS is a non-Category I, Quality Group C System.

g. For purposes of anlyzing the radiological dose consequences only, the loss of fuel pool cooling accident is evaluated against the criteria of 10 CFR 100. To perform the analysis of site boundary doses, the following assumptions were made:

1. As stated in response to Item 020.23 in Appendix E of this FSAR, an I-131 concentration in the fuel storage pool is assumed to be 60 μCi/g. Only I-131 is considered because doses from other nuclides, by comparison, are relatively negligible.

2. Heat released from the spent fuel is conservatively assumed to have a constant value of 9.9×10^6 Btu/hr (maximum decay heat resulting from Subsection 9.1.3.1.b.3) for a period of 30 days after the assumed loss of the fuel pool cooling system. For purposes of evaluating the radiological dose consequences only, it is conservatively assumed that no other heat removal method is available except for pool boiling and that the time to achieve pool boiling is zero. Makeup water is assumed to be provided at a rate equal to that of boiling and thus

maintains the full pool water volume at a constant value of approximately 48,000 ft^3. ~~The~~ Potential make-up sources are ~~listed in Table~~ the RHR service water, condensate storage, and fire protection system.

3. The iodine in the pool water is assumed to be released from the pool at a rate that corresponds to the boiling rate with the application of a partition factor of 10, and to be released to the environment via the SGTS with a removal efficiency of 99 percent.
4. The variation of iodine concentration in the fuel pool as a function of time is calculated realistically to account for decay, boiling, and the addition of makeup water. Two cases are considered: one assumes the makeup water to contain no radioactivity and the other assumes an unlimited supply of makeup water at an initial concentration of 60 µCi/g.

h. The FPCCS is designed to achieve the following additional functions:

1. Minimize corrosion product buildup and control water clarity, through filtration and demineralization, so that the fuel assemblies can be efficiently handled under water.

2. Minimize fission product concentration in the water that could be released from the pool to the Reactor Building environment.

3. **Monitor fuel storage pool water level and maintain a water level above the fuel sufficient to provide shielding for normal building occupancy.**

4. Maintain the pool water temperature at less than 150°F, with the heat loading resulting from the removal of a full core following a normal refueling. This is achieved by being able to interconnect the RHR system and the FPCCS.

5. Preclude siphoning the spent fuel pool by providing siphoning breakers on all lines penetrating the spent fuel pool.

9.1.3.2 System Description

The FPCCS cools the fuel storage pool by transferring decay heat through heat exchangers to the Reactor Building closed cooling water (RBCCW) system, as shown in Figure 9.1-23. Water purity and clarity in the fuel storage pool, reactor well pool, and dryer-separator storage pool are maintained by filtering and demineralizeing the pool water as shown in Figure 9.1-24.

The FPCCS is comprised of two trains, each of which has 50 percent filter capacity. Each train is designed to remove 5.0×10^6 Btu/hr at 125°F pool water temperature and 95°F RBCCW temperature (Table 9.1-1). The system consists of two fuel pool cooling pumps, two heat exchangers, two filter-demineralizers, two skimmer surge tanks, and associated piping, valves, and instrumentation. The two fuel pool cooling pumps are connected in parallel, as are the two heat exchangers. The pumps and heat exchangers are located in the Reactor Building below the level of the bottom of the fuel storage pool.

The filter-demineralizer units are located in the Radwaste Building in separate shielded cells, with enough clearance to permit removing filter elements from the vessels. Each cell contains only the filter-demineralizers and piping. All valves (such as inlet, outlet, recycle, vent and drain) are located on the outside of one shielding wall of the cell, together with necessary piping and headers, instrument elements, and controls. Penetrations through shielding walls are located so as not to compromise radiation shielding requirements (Subsection 12.1.2).

The pumps circulate the pool water in a closed loop, taking suction from the skimmer surge tanks through the heat exchangers, circulating the water through the filter-demineralizers, and discharging through diffusers at the bottom of the fuel storage pool. The cooled water traverses the pool, picking up heat and debris before starting a new cycle by discharging over the skimmer weirs and scuppers into the skimmer surge tanks. The normal makeup water source for the system is provided from the condensate storage tank to the skimmer surge tanks.

Back up cooling is provided to the fuel pool by means of a permanently piped cross-tie to the RHR System. In this mode of operation one RHR pump and the corresponding RHR division heat exchanger will provide the means to cool the fuel pool. This cooling circuit is established by opening cross-tie valves V8-3264 and V8-3029 and closing FPCCS valves V8-3006 and V8-3253(. (See Figure 9.1-23). For the designed piping configuration, the RHR pump will deliver approximately 5400 gpm,and the RHR heat exchanger will remove approximately 35×10^6 BTU/hour at 125°F pool water temperature, ~~and 30°F RHR service water temperature~~ (See Table 9.1-1.) To ~~move~~ ensure the availability of backup cooling via the RHR System, the cross-tie piping, the FPCCS piping from the skimmer tanks to the first anchor downstream of valve V8-3006, and the FPCCS piping from the first anchor upstream of valve V8-3253 to the fuel pool diffusers ~~on~~ are Category I.

Both FPCCS heat exchangers operating in parallel are designed to remove the maximum heat load produced by various combinations of spent fuel discharged from the equilibrium fuel cycle at the time the RHR system is isolated from the pool, plus the heat being released by batches discharged at previous refueling (see Subsection 9.1.3.1). The FPCCS is designed to maintain the fuel storage pool water temperature below 125°F while removing the maximum normal heat load from the pool with the RBCCW temperature at its maximum.

The pool operating temperature is permitted to rise approximately 25°F above the normal operating temperature of

125°F when larger than normal batches of fuel are stored or when the FPCCS becomes incapicitated. In this case, either of the heat exchangers in the RHR system can be used in conjunction with the FPCCS to supplement pool cooling. Table 9.1-1 also lists the characteristics of an RHR subsystem in fuel pool cooling mode.

The design of the fuel storage pool is such that the top of the stored fuel is at a lower elevation than the bottom of the pool gate between the reactor well and fuel storage pool. There are no connections to the fuel storage pool that could drain the pool below the elevation of the bottom of the pool gate when the gate is removed for refueling, or below the normal pool level when the gate is in place. To prevent water from being siphoned out of the pool, the piping entering the fuel storage pool is fitted with check valves and vacuum breakers above the pool elevation. A level indicator, mounted at the valve rack, monitors reactor well water during refueling. A high rate of leakage through the refueling bellows assembly, drywell to reactor seal, or the fuel storage pool gates is indicated on the operating floor instrument racks.

Fuel storage pool water is continuously recirculated. The circulation patterns within the reactor well and storage pool are established by the placement of the diffusers and skimmers so as to sweep particles disloged during refueling operations away from the work area and out of the pool.

For refueling operations, the reactor well and dryer-separator storage pools are filled by first transferring the required fill water from the condensate storage tank to the condenser hotwell. After the vessel head is removed, the fill water is transferred from the hotwell through the feedwater spargers and into the reactor well with the condenser-heater feed pumps.

Clarity and purity of the pool ·ater are maintained by a combination of filtering and ion exchange. The cleanup system has sufficient capacity to ensure pool water clarity and purity. The water purity is maintained by monitoring the demineralizer conductivity and differential pressure with periodic sampling and anlysis of spent fuel storage pool water. The filter-demineralizers maintain water purity within chemical limits specified below:

Fuel Pool	Chemical Limits	Demineralizer Effluent
Conducitivty	≤3 umho/cm at 25°C	≤1 umho/cm at 25°C
Chloride	≤500 ppb	≤ 50 ppb
pH	5.3-7.5 at 25°C	6.0-7.5 at 25°C
Total insolubles	≤ 1 ppm	

Demineralizer differential pressure limit: 25 psi.

The system flow rate is larger than that required for two complete water changes per day of the fuel storage pool, or one change per day of the fuel storage, reactor well, and dryer-separator pools.

The maximum system flow rate is twice the flow rate needed to maintain the specified water quality. Particulate matter is removed by the filter-demineralizer unit in which finely divided, powdered, ion-exchange resin serves as the filtering medium. Alternatively, a combination of powdered resin and precoated material such as cellulose may be used as the disposable filter medium. The filter elements are stainless steel mesh elements mounted vertically in a tube sheet and replaceable as a unit. The filter vessel is constructed of carbon steel and coated with a phenolic resin material.

Spent fuel storage pool water and demineralizer effluent are sampled and analyzed once per week. Instrument readings for conductivity and differential pressure are taken once per shift. Alarms sound in the control room if demineralizer conductivity, flow, or differential pressure limits are attained so that corrective action may be initiated. Backwashing and precoating operations are controlled from a local panel in the Radwaste Building. The spent filter medium is removed from the elements by backwashing with air and condensate and then is flushed to the waste sludge tank.

A post-strainer in the effluent stream of the filter-demineralizer limits the migration of filter material. The filter-holding element can withstand a differential pressure greater than the developed pump head for the system.

System instrumentation is provided for both automatic and remote-manual operations. A low-low level switch stops the circulating pumps when surge tank reserve capacity is reduced to the volume that can be pumped in 1 minute with one pump at rated capacity. Manual control for the circulating pumps is either from local panels or the control room panel. Pump low suction pressure automatically turns off the pumps.

The FPCCS has alarm functions for cooling pump low discharge pressure, refueling bellows seal leakage, fuel pool gate reactor well seal leakage, skimmer surge tank high level, fuel pool pool high level, and skimmer surge tank low level. All of these functions give a common alarm signal to the main control room; for example, fuel pool cooling system trouble. Each function also has a light, located on local control panels, which determines the cause of the common alarm in the main control room. In addition, there are specific alarms in the control room for the fuel pool high temperature, fuel pool low level, and fuel pool demineralizer trouble.

The local control panels receive power from a standby source if normal power is not available. Circulating pump motor loads are considered nonessential loads and will be operated as required under accident conditions.

9.1.3.3 Safety Evaluation

The fuel pool cooling system maintains the fuel pool bulk temperature below 125°F with the design decay heat load. The fuel pool cooling and RBCCW pumps are powered from redundant buses; this ensures continued cooling operation. The RHR system provides a safety source of emergency makeup water and redundant heat removal capability.

No inlets, outlets, or drains are provided that would permit the spent fuel pool to be drained below a safe shielding level. Lines extending below this level are quipped with siphon breakers, check valves, or other suitable devices to prevent inadvertent pool drainage. The line draining the space between the two gates is sufficiently high to preclude draining excessive water above the spent fuel storage racks.

Except during refueling operations, the fuel pool will be isolated from the rea ctor head cavity and dryer-separator storage pool by two redundant watertight gates that close the opening through which spent and new fuel is transported to and from the fuel pool. The bottom of the gate opening is above the top of the fuel storage racks in the bo m of the fuel pool to ensure that the stored fuel fuel can never be uncovered.

The only interconnection between the cooling and cleanup subsystems is the fuel pool itself. The cleanup pumps' return line is provided with a siphon breaker.

The decay heat load in the fuel pool may vary widely because of various possible combinations of:

a. The number of groups and the respective irradation periods of spent fuel assemblies in the pool (see Subsection 9.1.3.1.b and e)

b. The duration of time-after-shutdown for each of the spent fuel groups.

Decay heat has been calculated for the various fuel assembly discharge combinations and assumptions of Subsection 9.1.3.1. Combination 9.1.3.1.b.3/one-third core 18 month discharges (6 with 21 days cooling) has resulted in the greatest heat release to the pool of 9.9×10^6 BTu/hr (2.90 MWt).

Under abnormal conditions of high fuel pool decay heat load and/or FPCCS capacity restriction (e.g., due to maintenance), the heat load may exceed the capacity of the operating portion of the FPCCS. Should this occur, an RHR loop can be aligned to take suction from, and discharge to, the fuel pool. The use of the RHR system in the fuel pool cooling mode makes one LPCI subsystem inoperable in terms of being ready for emergency core cooling. The Technical Specifications will note this equivalence and require the same ACTION as if the Subsystem were inoperable.

The heat load to the pool is caused by the decay heat of the fission products and the activated heavy elements (U-239 and Np-239) contained in the spent fuel assemblies stored in the pool. Table 9.1-2 presents the fractional decay heat as a function of time after shutdown determined with the method given in BTP ASB 9-2. This data is based on a full power operating period (t_o) OF 4-1/2 years which is consistent with a 1/3 core, 18 month equilibrium fuel cycle. The number of fuel assemblies per discharge and the decay heat contribution for each discharge are also given in Table 9.1-2. The actual decay heats in MW for fuel assemblies discharged in consecutive years are presented in Table 9.1-3 are computed as follows:

$$QDKP\ (t_s) = 3293\ MWt \times \frac{P}{P_o}\ (t_o, t_s) \times \frac{1}{3}$$

where

$QDKP\ (t_s)$ = decay heat of the fuel assemblies that have been stored in the pool for t_s sec., MWt

3293 MWt = rated thermal output of the core

$\frac{P}{P_o}\ (t_o, t_s)$ = fractional decay heat

$\frac{1}{3}$ = Fraction of full core discharged per refueling.

Table 9.1-3 gives the cumulative pool heat load and quality of fuel stored in the pool versus time after the initial discharge to the pool. These data are also shown on Figure 9.1-25. Also shown is the relation between the maximum heat load to the pool (shown as the upper circles in the figure) and the number of spent fuel assemblies stored.

It is shown that for 1330 assemblies, the maximum heat load is 2.90 MW, which is below the present heat removal capacity of 2.92 MW. If the cooling period with the RHR system during refueling is extended from 21 Days to 30 Days, the Bulk Pool Heat Load for the 1/3 core, 18 month case is reduced from 2.90 MW to 2.57 MW.

If, in the unlikely event, the pool temperature exceeds 125°F because of greater than design decay heat load and/or degraded performance of FPCCS, one loop of the RHR system will be employed to control the pool temperature. However, as stated previously, the RHR loop will be considered to be equivalent to inoperable and Technical Specification limits will apply to plant operation with one RHR loop inoperable.

Item 020.23 in Appendix E.2 addressed the consequences for loss of cooling to the fuel storage pool. A revision has been performed to reflect the use of a high-density rack configuration in the fuel storage pool. Revised calculations indicate that the 2-hour thyroid (inhalation) dose at the site boundary would be 17 mrem, and the 30-day thyroid (inhalation) dose at the low population zone would not exceed 29 mrem.

The meteorological condition assumed for the accident is the fifth percentile short-term (accident) X/Q's for actual site meteorological data provided from Detroit Edison's 60-m tower and as reported to, and accepted by, the NRC staff (NRC letter dated April 26, 1976, G. W. Knighton to H. Tauber, Reference 6). These data are presented in Table 9.1-4.

The calculations estimate the 2-hour thyroid (inhalation) dose at the site boundary to be 17 mrem for both radioactive and nonradioactive makeup water. The 30-day thyroid (inhalation) dose at the low population zone for radioactive makeup is 29 mrem; whereas for nonradioactive makeup, the 30-day dose is 23 mrem. Table 9.1-4 presents the major parameters used in the calculations.

Results indicate that the dose from this postulated accident would not exceed a fraction of 10 CFR 100 limits.

In summary, the spent fuel storage pool cooling system's design, siphon breaking piping arrangement, redundant transfer gates, emergency makeup water supply from the RHR service water system, and RHR backup capability provide a completely reliable system for the storage and cooling of spent fuel.

9.2.3.4 Testing and Inspection

Prior to power operation following a refueling outage, a determination will be made that the heat generation rate in the fuel pool is within the current capacity of the FPCCS to maintain the pool temperature at 125°F or less.

The first valves in all lines and branches connecting to the pool are subject to tests as category B and C values under Section XI of the ASME B&PV Code. These include the valves routing the water to either the FPCCS or the RHR and the vacuum breakers on the return lines.

No special tests are required for instrumentation on the FPCCS. The instrumentation will be subjected to routine testing.

The FPCCS preoperational test program will be conducted as discussed in Chapter 14.

MLB/dk
3-18-81

TABLE 9.1-1 FUEL POOL COOLING AND CLEANUP SYSTEM

Total Pool, Well, and Pit Volume	107,000 ft^3
Fuel Storage Pool Volume	48,000 53,050 ft^3
Long-Term Heat Load	<3.95 x 10^6 Btu/h 95
Design Heat Load	9.9 7.9 x 10^6 Btu/h (100°F cooling water inlet)
Maximum Heat Load (RHR required)	20.6 x 10^6 Btu/h

Fuel Pool Cooling Water Pumps

Quantity	2
Type	Horizontal, centrifugal
Design Flow/TDH (each)	550 gpm/300 ft
Motor hp	60 hp

Fuel Pool Cooling Heat Exchangers

Quantity	2	
Design Duty @ 95 100°F RBCCW[(a)]	5.0 4.95 x 10^6 Btu/h	
Design Code	ASME Boiler and Pressure Vessel, Section VIII	
	Shell Side	Tube Side
Fluid Circulated	RBCCW(a)	Spent fuel pool water
Temperature in	95°F	125°F
Fluid Flow	800 gpm	550 gpm
Number of Passes	1	2
Material	CS, SA-106B	SS-304, SA-249
Design Pressure	150 psig	200 psig
Design Temperature	150°F	150°F

Fuel Pool Filter Demineralizers

Type	Pressure precoat
Quantity	2
Design Filter Area	270 ft^2
Filter Capacity	550 gpm
Maximum Pressure Drop	20 psi
Design Code	ASME Boiler and Pressure Vessel, Section VIII
Holding Pump Flow	27 gpm
Precoat Flow	405 gpm

Fuel Pool Cooling Capacity of RHR

Service Water Temperature	85°F	85°F	89°F	89°F
Fuel Pool Temperature	125°F	150°F	125°F	150°F
Cooling Capacity Btu/hr	39x10^6	64x10^6	35x10^6	60x10^6

(a) Maximum temperature of RBCCW is 95°F at 85°F lake water temperature. When lake water temperature is 75°F 60°F or below, the RBCCW is controlled to 85°F 70. The heat removal capacity of one of the FPCC system heat exchangers at 85°F RBCCW is approximately 6.3 x 10^6 Btu/h. [illegible]

9.1 REFERENCES

1. Joseph Oat Corporation, Licensing Input on High Density Spent Fuel Racks for Fermi II Project, Report TM-586, Camden, New Jersey.

2. S. Levy and J. P. D. Wilkinson, The Component Element Method in Dynamics with Application to Earthquake and Vehicle Engineering, McGraw-Hill, New York, New York, 1976.

3. Joseph Oat Corporation, A Method for Hydro-Thermal Analysis of High Density Fuel Racks, Standard Document No. 20, Camden, New Jersey.

4. Southern Science Applications, Inc., Benchmark Calculations for Spent Fuel Storage Racks, Report SSA-127, Dunedin, Florida. 32

5. Southern Science Applications, Inc., Nuclear Criticality Analysis of the Spent Fuel Storage Rack Design for the Enrico Fermi Atomic Power Plant, Report SSA-131, Dunedin, Florida.

6. NRC letter dated April 26, 1976, G. W. Knighton to H. Tauber.

TABLE 9.1-2

FRACTIONAL DECAY HEAT VERSUS TIME AFTER SHUTDOWN

4½ YEARS IRRADIATION, ⅓ CORE, 18 MONTH CYCLE

TIME AFTER SHUTDOWN, t_s	t_s (SEC)	P/P_o	NO. ASSEMBLIES DISCHARGED TO POOL	DECAY HEAT PER DISCHARGE, Q_{DKP} (MWt)
21 DAYS	1.814×10^{6}	1.974×10^{-3}	255	2.1670
1.5 YEARS	4.915×10^{7}	2.263×10^{-4}	255	0.2494
3.0 YEARS	9.648×10^{7}	1.341×10^{-4}	255	0.1472
4.5 YEARS	1.438×10^{8}	1.099×10^{-4}	255	0.1207
6.0 YEARS	1.911×10^{8}	1.013×10^{-4}	255	0.1112
7.5 YEARS	2.385×10^{8}	9.654×10^{-5}	255	0.1060

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TABLE 9.1-3

CUMULATIVE POOL HEAT LOAD AND
QUANTITY OF FUEL STORED IN POOL
VERSUS TIME AFTER INITIAL DISCHARGE
1/3 CORE, 18 MONTH CYCLE, 21 DAYS COOLING

TIME AFTER INITIAL DISCHARGE (YEARS)	DECAY HEAT PER DISCHARGE QDKP (MWt)	QUANTITY OF FUEL STORED AFTER DISCHARGE (ASSEMBLIES)	BULK POOL HEAT LOAD BEFORE DISCHARGE (MWt)	BULK POOL HEAT LOAD AFTER D[illegible] (MWt)
0	2.1670	255	0	2.1670
1.5	0.2484	510	0.2484	2.4155
3.0	0.1472	765	0.3956	2.5626
4.5	0.1207	1020	0.5163	2.6833
6.0	0.1112	1275	0.6275	2.7945
7.5	0.1060	1530	0.7335	2.9005

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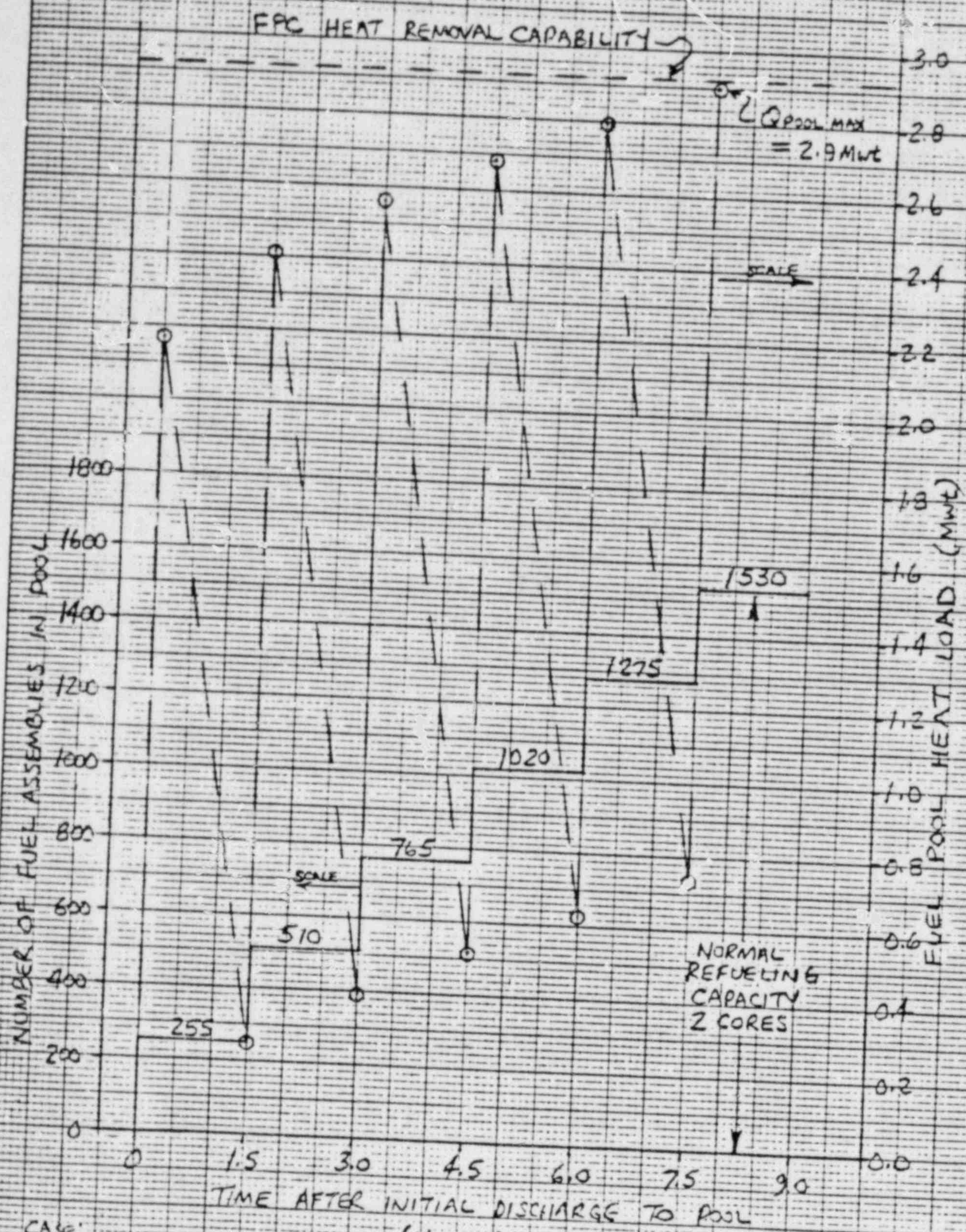

CASE:
1/3 CORE, 18 MONTH CYCLE
t_o = 4½ YRS, t_s = 21 DAYS

FIGURE 9.1-25

CUMULATIVE POOL HEAT LOAD AND FUEL ASSEMBLY STORAGE

46 1320

K·E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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G.T. [illegible] V. W. + Gilbert
E. Russo C. M. Johnson (via telecopy)
TM. Boteh

Enrico Fermi Unit 2 High Density
Spent Fuel Storage System

1. In accordance with item 1.2(1) of the April 14, 1978 generic letter on spent fuel expansions described and discuss the potential for criticality being achieved if fuel assemblies are inadvertently placed around the perimeter of the conventional aluminum storage racks containing fuel assemblies.

2. Amendment 32 described five different possible heat loads without identifying those that determine the spent fuel pool heat removal system requirements. In this regard provide the following information.

(a) Identify the particular [illegible] discharge cycles that define the spent fuel pool cooling system requirements

(b) Indicate the minimum elapsed time between shutdown and when all of the discharge fuel is in the spent fuel storage pool.

(c) Verify that all calculated values of decay heat have been obtained in accordance with the guidance in ASB Technical position 9-2. It should be noted that ASB TP 9-2 presumes the reactor had been operating at rated power i.e., it is not acceptable to assume the reactor had been operating at 80% of rated power

(d) Using that normal refueling cycle which yields the maximum decay heat load, provide a plot of the cumulative spent fuel pool heat load versus time si[illegible]r to Figure 9.1-25 in Amendment 32.

Superimpose on the plot the rated heat removal capacity of the spent fuel pool cooling system, the heat removal capacity of the RHR system and the combined heat removal capacity of the spent fuel pool cooling system and the RHR system.

(e) In each occasion in the above plot where the total normal cumulative heat load exceeds the rated capacity of the spent fuel pool cooling system indicate the additional decay time (resident turn in the spent fuel pool) before the heat load will decay to a value equal to the capacity of the spent fuel pool cooling system i.e. the RHR system is no longer required to augment the spent fuel pool cooling system

(f) Using the cumulative decay heat valves developed above provide a plot of the total heat load assuming a full core discharge were to occur instead of a noraml discharge at each refueling periods. Superimpose on the plot the heat removal capacity of the spent fuel pool cooling system, the RHR system and the combined spent fuel pool cooling system and RHR system

(g) In each occasion where the above ~~total~~ maximum cumulative heat load plot exceeds the rated capacity of the spent fuel pool cooling system indicate the required additional decay time in the spent fuel pool before the heat load will decay to a value equal to the capacity of the spent fuel pool cooling system

(h) Describe and discuss the methods that will be employed to verify that the decay heat load in the pool is equal to or less than the capacity of the spent fuel pool cooling system and therefore the RHR system can safety be returned to its normal safety function.

3- Assuming the maximum heat load in the spent fuel pool (include a full core discharge) and a complete loss of external pool cooling, indicate the time interval before boiling would occur and indicate the boil off rate. In regard to the identified sources of makeup water given in compliance with Regulatory Guide 1.13 Amendment 1 dated November 1975 for each makeup source describe and discuss the quantity of makeup water available, the makeup rate and time required before it can be available at the pool.

4 Assuming the reactor is operating at power, and the spent fuel pool cooling system fails when the pool has a heat load of 7.9×10^6 BTU/hr. Indicate the elapsed time before boiling occurs. Relate this time interval to the time interval required to place the RHR system in the spent fuel pool cooling mode of operation. The discussion is to include the plant conditions that must be met before the RHR system can be made available for cooling the pool

5. Describe and discuss the assumptions and input data used in establishing the heat removal capacity of the RHR system when operating in the spent fuel pool cooling mode.

6. In regard to the ability of the high density storage racks to protect the stored spent fuel assemblies from load drops the staff has assumed in the

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past that all lesser loads when dropped from their maximum elevation would cause less damage, i.e., the product of the weight of the load times the drop height would be less that the weight of one fuel assembly and its associated handling tool when dropped from its maximum elevation above stored spent fuel. Verify that this assumption is correct.

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